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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1150

DEVELOPMENT OF A COOL PROPELLANT
FOR THE 5"/54 CALIBER GUN

8th Partial Report

BALLISTIC TEST OF COOL PROPELLANTS
EX-7016 - EX-7021 INCLUSIVE, EX-7038, AND
EX-7048 - EX-7050 INCLUSIVE

FINAL Report

Task
Assignment NPG-Re2d-61-1-53

Copy No. 11

Classification CONFIDENTIAL
SECURITY INFORMATION

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

PART A

SYNOPSIS

1. This is the eighth partial report on Task Assignment NPG-Re2d-61-1-53, the "Development of a Cool Propellant for the 5"/54 Caliber Gun", and the final report on "Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive".
2. From the results of the subject tests, it is concluded that:
 - a. None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) were satisfactory at 3000-3100 f/s velocity in the 22-24 tsi pressure range within the limitation of 3!5 PPD (Production Packing Depth).
 - b. Difficulty in establishing and maintaining optimum powder packing conditions was experienced due to the soft and fish-scale surface structures of EX-7016 through EX-7021. For the assessed charge of 20.75 lb. of EX-7020, an increase of 1!5 in PPD was obtained by graphiting the powder.
 - c. EX-7038 was unsatisfactory as a replacement for EX-6883.
 - d. Mono-perforated powders are readily ignitable and show possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.
 - e. No appreciable differences in ballistics were obtained between the EX-23-1 and Mk 41-0 (60 lb.) projectiles.
3. Preliminary firings indicate that propellants with higher relative ignitability and larger percent nitrate nitrogen are more sensitive to basic ignition changes.
- f. The pressure-time curves obtained with the subject propellants had steps occurring in the pressure-rise region and in general were rougher than those obtained with EX-6822 or EX-6883.

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PART B

INTRODUCTION

1. AUTHORITY:

The tests reported herein were authorized by references (b), (c), and (d) and conducted under Task Assignment NPG-Re2d-61-1-53 as established by reference (a).

2. REFERENCES:

- a. BUORD Conf ltr Re2d-CNB:aph Ser 42692 of 29 July 1952
- b. BUORD Conf ltr Re2d-CNB:aph Ser 44705 of 12 Sept 1952
- c. BUORD Conf ltr NP9 Re2d-ERD:jd Ser 47824 of 18 Nov 1952
- d. BUORD Conf ltr NP9 Re2d-ERD:dad Ser 48931 of 10 Dec 1952
- e. BUORD Conf ltr Re2d-ERD:aph Ser 47419 of 7 Nov 1952 to E. I. duPont Company
- f. NPG Conf Report No. 984 of 18 Aug 1952
- g. Description Sheets of Manufacture and Closed Bomb Data
- h. USNPF Conf Report No. 40 (NAVORD Report No. 3011) of 15 May 1952
- i. NPG Conf Report No. 873 of 17 Dec 1951

3. BACKGROUND:

Reference (a) established the general task for the development of cool powders for the 5"/54 caliber gun. Reference (b) requested that EX-7016 through EX-7021 be fired for ballistic assessment in the 5"/54 caliber gun with the 60 lb. projectile in the 22-24 ton pressure range at a velocity of 3000 to 3100 f/s. Reference (b) described these propellants as cool picrite powders with a nominal flame temperature around 2350°K, prepared by duPont to determine the effect of variation in nitrate nitrogen content on ignition and gun ballistics. Reference (c) requested that EX-7038 be fired for charge determination in the 5"/54 caliber gun and described it as a 2350°K (nominal) picrite propellant for possible use as a replacement for EX-6863 in the continuation of the rapid fire-wear program as reported in reference (f). Reference (d) requested EX-7048, 7049 and 7050 (mono-perforated) be fired for ballistic assessment in the 5"/54 caliber gun. Reference (d) described these propellants as cool picrite powders prepared in accordance with reference (e). Reference (h) described the development of a method for the determination of the ignitability of propellants.

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4. OBJECT OF TEST:

- a. To determine whether EX-7016 to EX-7019 are ballistically suitable for the 5"/54 caliber gun using the 60 lb. projectile at a pressure of 22-24 tsi and velocity between 3000 and 3100 f/s.
- b. To determine the effect of increased nitrate nitrogen content on ignition and ballistics.
- c. To determine whether EX-7038 is a satisfactory replacement for EX-6883.
- d. To determine whether mono-perforated propellants (EX-7048-7049-7050) are suitable ballistically for the 5"/54 caliber gun.
- e. To determine if the subject propellants are ballistically satisfactory within a PPD (Production Packing Depth) of 3!5. (This value allows for manufacturing tolerances between different powder lots and is essential in the assembly of 5"/54 cone-crimped ammunition).

5. PERIOD OF TEST:

| | |
|------------------------------|---|
| a. Dates of Project Letters: | 29 July 1952 12 Sep 1952 7 Nov 1952 18 Nov 1952 10 Dec 1952 |
| b. Dates Material Received: | |
| EX-7016 to 7019 inclusive | 7 Aug 1952 |
| EX-7038 | 14 Oct 1952 |
| EX-7048-7049-7050 | 10 Dec 1952 |
| c. Date Commenced Test: | 13 Dec 1952 |
| d. Date Test Completed: | 2 Feb 1953 |

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PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

Reference (g) gave in detail the powder description and closed bomb data. A summary of the data follows:

| <u>Actual Composition</u> | <u>EX-7016</u> | <u>EX-7017</u> | <u>EX-7018</u> |
|---------------------------|----------------|----------------|----------------|
| Nitrocellulose (13.20%N) | 20.42% | 20.33% | 20.58% |
| Nitroglycerin #1 | 19.48 | 19.18 | 19.37 |
| Picrite | 50.51 | 51.12 | 50.49 |
| Centralite | 1.71 | 1.54 | 1.55 |
| Dibutylphthalate | 7.88 | 7.83 | 8.02 |
| Lead Carbonate (added) | 0.93 | 0.84 | 0.94 |

| <u>Actual Composition</u> | <u>EX-7019</u> | <u>EX-7020</u> | <u>EX-7021</u> | <u>EX-6883</u> |
|---------------------------|----------------|----------------|----------------|----------------|
| Nitrocellulose (13.20%N) | 31.12 | 31.00 | 30.48 | 19.98 |
| Nitroglycerin #1 | 18.85 | 19.28 | 19.43 | 14.61 |
| Picrite | 39.41 | 39.64 | 39.58 | 58.40 |
| Centralite | 2.00 | 1.56 | 2.01 | 1.47 |
| Dibutylphthalate | 8.62 | 8.52 | 8.50 | 5.54 |
| Lead Carbonate (added) | 0.98 | 0.92 | 1.00 | 1.01 |

| <u>Actual Composition</u> | <u>EX-7038</u> | <u>EX-7048</u> | <u>EX-7049</u> | <u>EX-7050</u> |
|---------------------------|----------------|----------------|----------------|----------------|
| Nitrocellulose (13.20%N) | 19.16 | 19.90 | 19.20 | 19.08 |
| Nitroglycerin #3 | 15.29(*) | 15.36 | 14.69 | 14.42 |
| Picrite | 59.16 | 58.12 | 58.04 | 58.61 |
| Centralite | 1.81 | 2.02 | 1.97 | 1.88 |
| Dibutylphthalate | 4.58 | 4.60 | 4.94 | 4.76 |
| Lead Carbonate (added) | 0.96 | 0.95 | 0.96 | 0.99 |

* Nitroglycerin #1 with EX-7038

Reference (g) also gave the following information:

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| Sample | Calc. Flame Temp. (°K) | Grain Dimensions | | | RQ (%) | RF (%) | Relative Ignitability (%) |
|---------|------------------------|------------------|----------------|------------------|-----------|---------------------------------|---------------------------------|
| | | Length (in.) | Diam. (in.) | Av. Web (in.) | | | |
| EX-7016 | 2334 | 0.5460 | 0.2377 | 0.0422 | 7 | 105.9(a) 110.3(b) | 97.8(a) 6.42 |
| EX-7017 | 2348 | 0.7150 | 0.2952 | 0.0512 | 7 | 82.8(a) 98.9(a) 111.6(b) | 98.9(a) 180 |
| EX-7018 | 2356 | 0.7400 | 0.3304 | 0.0595 | 7 | 89.9(b) 92.1(a) 98.0(a) | 190 |
| EX-7019 | 2381 | 0.5490 | 0.2323 | 0.0415 | 7 | 78.2(b) 103.5(a) 112.5(b) | 111.0(b) 99.5(a) 112.7(b) |
| EX-7020 | 2387 | 0.6613 | 0.3029 | 0.0510 | 7 | 72.9(a) 93.5(b) 111.5(b) | 97.3(a) 110.4(b) 112.8(b) |
| EX-7021 | 2332 | 0.7490 | 0.3238 | 0.0689 | 7 | 79.2(b) 88.5(a) 97.8(b) | 88.2(a) 98.2(a) 100.7(d) |
| EX-7038 | 2435 | 0.7220 | 0.2873 | 0.0504 | 7 | 90.8(a) 96.8(b) 91.4(c) | 96.9(a) 113.2(b) 97.0(a) |
| EX-7048 | 2436 | 0.3709 | 0.1428 | 0.0626 | 1 | 102.9(d) 79.5(b) 75.0(c) | 100.7(d) 111.1(b) 95.3(a) |
| EX-7049 | 2387 | 0.4270 | 0.1578 | 0.0705 | 1 | 84.4(d) 75.6(b) 80.4(d) | 98.8(d) 110.8(b) 98.6(d) |
| EX-7050 | 2393 | 0.4605 | 0.1778 | 0.0773 | 1 | 71.5(o) 80.4(d) | 95.0(o) 114.1(b) |
| EX-6383 | 2378 | 0.5750 | 0.2498 | 0.0457 | 7 | 108.2(b) | 5.03 |

(a) Based on EX-6833 as 100% at 90°F.
 (b) Based on EX-6586 as 100% at 90°F.
 (c) Based on EX-6862 as 100% at 90°F.
 (d) Based on EX-7038 as 100% at 90°F.
 (e) Based on Cordite N powder as 100%. (reference (h)).

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7. PROCEDURE:

a. The subject propellants were fired in either the Mk 16-0 or Mk 18-0 5"/54 caliber guns. Comparative firings were conducted with related powders listed in references (f) and (i). All tests were conducted with the 60 lb. projectile for 3000-3100 f/s velocity and 22-24 tsi pressure.

Muzzle velocities, maximum pressures (copper crusher), ejection times, and visual observations of flash and smoke were obtained. Pressure-time records were obtained on representative powders.

b. Tests were conducted to determine powder packing depth differences with graphited and non-graphited powder.

8. RESULTS AND DISCUSSION:

The results of the subject tests are given in detail in the Appendices and are summarized below:

a. Uniformity:

| <u>Date</u> | <u>Gun No.</u> | <u>Powder</u> | <u>PPD (in.)</u> | <u>Charge (lbs.)</u> | <u>Velocity (f/s)</u> | <u>Pressure (t.s.i.)</u> | <u>Ejec. Time (sec.)</u> | <u>No. of Rds.</u> |
|-------------|----------------|---------------|------------------|----------------------|-----------------------|--------------------------|--------------------------|--------------------|
| 12-13-52 | 16076 | EX-6883 | 4.6 | 20.15 | 2971±2 | 20.0±0.1 | 0.021±0.001 | 5 |
| " | " | EX-7016 | 6.0 | 18.50 | 2850±0 | 21.5±0.3 | 0.018±0.001 | 2 |
| " | " | EX-7017 | 5.1 | 18.50 | 2689±4 | 14.3±0.2 | 0.019±0.000 | 2 |
| " | " | " | 1.4 | 21.10 | 2954±1 | 18.4±0.2 | 0.019±0.001 | 3 |
| " | " | EX-7018 | 3.1 | 20.00 | 2637±8 | 12.9±0.3 | 0.022±0.001 | 2 |
| " | " | EX-7019 | 5.9 | 18.50 | 2930±3 | 26.6±0.4 | 0.017±0.001 | 2 |
| " | " | EX-7020 | 4.9 | 18.50 | 2757±4 | 15.8±0.2 | 0.020±0.002 | 2 |
| " | " | " | 1.4 | 20.90 | 3004±8 | 20.2±0.1 | 0.017±0.001 | 2 |
| " | " | EX-7021 | 4.6 | 19.00 | 2579±9 | 12.4±0.1 | 0.019±0.000 | 2 |
| " | " | " | 1.4 | 21.20 | 2809±4 | 15.2±0.1 | 0.021±0.001 | 2 |
| " | " | EX-7038 | 7.2 | 18.00 | 2659±2 | 14.2±0.1 | 0.021±0.001 | 3 |
| " | " | " | 1.4 | 22.20 | 3070±4 | 20.7±0.3 | 0.018±0.001 | 3 |
| 12-19-52 | 14763 | EX-6883 | 4.6 | 20.15 | 2990±7 | 20.9±0.5 | 0.019±0.000 | 5 |
| " | " | EX-7020 | 4.9 | 18.50 | 2771±5 | 16.4±0.2 | 0.018±0.001 | 3 |
| " | " | " | 1.6 | 20.75 | 3001±3 | 21.0±0.2 | 0.017±0.001 | 5 |
| " | " | EX-7038 | 7.2 | 18.00 | 2674±1 | 14.4±0.1 | 0.021±0.001 | 3 |
| " | " | " | 1.4 | 22.20 | 3059±5 | 20.9±0.3 | 0.018±0.001 | 5 |
| " | " | Blend (a) | 2.0 | 20.50 | 3007±7 | 21.8±0.3 | 0.016±0.000 | 5 |
| " | " | " | 5.7 | 18.00 | 2759±2 | 16.8±0.1 | 0.018±0.001 | 3 |
| " | " | EX-7020(b) | 3.1 | 20.75 | 2979±5 | 21.2±0.1 | 0.017±0.001 | 5 |

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EX-7038, and EX-7048 - EX-7050 inclusive

| <u>Date</u> | <u>Gun No.</u> | <u>Powder</u> | <u>PPD (in.)</u> | <u>Charge (lbs.)</u> | <u>Velocity (f/s)</u> | <u>Pressure (t.s.i.)</u> | <u>Ejec. Time (sec.)</u> | <u>No. of Rds.</u> |
|-------------|----------------|---------------|----------------------|--------------------------|---------------------------|---|------------------------------|------------------------|
| 12-19-52 | 14758 | EX-6883 | 4.6 | 20.15 | 2940±0 | 18.6±0.2 | 0.020±0.001 | 3 |
| " | " | EX-7020 | 1.6 | 20.75 | 2958±2 | 19.6±0.2 | 0.018±0.001 | 3 |
| " | " | EX-7038 | 2.3 | 21.50 | 2960±7 | 18.6±0.2 | 0.017±0.000 | 3 |
| " | " | Blend (a) | 2.0 | 20.50 | 2975±4 | 21.6±0.3 | 0.017±0.001 | 3 |
| " | " | EX-7050 | 7.8 | 18.65 | 2644±1 | 21.4±0.3 | 0.017±0.001 | 3 |
| " | " | EX-7020(b) | 3.1 | 20.75 | 2959±3 | 21.3±0.7 | 0.017±0.000 | 3 |
| 1-2-53 | 16077 | EX-7038 | 6.7 | 18.50 | 2725±2 | 15.1±0.0 | 0.019±0.001 | 2 |
| " | " | " | 3.0 | 21.00 | 2966±4 | 18.5±0.3 | 0.018±0.001 | 4 |
| " | " | " (c) | 3.0 | 21.00 | 2960±10 | 17.8±0.4 | 0.020±0.002 | 5 |
| " | " | EX-6822 | 7.3 | 18.50 | 2822±4 | 17.5±0.4 | 0.022±0.002 | 3 |
| " | " | " | 3.5 | 21.30 | 3076±5 | 22.0±0.2 | 0.019±0.001 | 5 |
| " | " | " (c) | 3.5 | 21.30 | 3076±7 | 21.8±0.3 | 0.019±0.002 | 5 |
| " | " | EX-6883 | 6.9 | 18.50 | 2826±6 | 17.2±0.2 | 0.020±0.000 | 3 |
| " | " | " | 3.0 | 21.30 | 3099±3 | 21.7±0.5 | 0.019±0.001 | 5 |
| " | " | " (c) | 3.0 | 21.30 | 3102±2 | 21.9±0.3 | 0.019±0.001 | 5 |
| 1-22-53 | 14763 | EX-7019(d) | 8.1 | 17.00 | 2782±3 | 24.1±0.2 | 0.019±0.001 | 2 |
| " | " | " (e) | 8.1 | 17.00 | 2782±2 | 22.8±0.5 | 0.019±0.001 | 2 |
| " | " | " (f) | 8.1 | 17.00 | 2766±1 | 20.5±0.1 | 0.019±0.001 | 2 |
| " | " | EX-7017(d) | 1.4 | 21.10 | 2948±3 | 19.0±0.1 | 0.019±0.001 | 2 |
| " | " | " (e) | 1.4 | 21.10 | 2928±1 | 17.8±0.0 | 0.019±0.001 | 2 |
| " | " | " (f) | 1.4 | 21.10 | 2915±1 | 17.1±0.1 | 0.019±0.000 | 2 |
| " | " | EX-6883(d) | 4.4 | 20.15 | 2957±4 | 20.0±0.3 | 0.021±0.001 | 5 |
| " | " | " (e) | 4.4 | 20.15 | 2949±2 | 19.9±0.2 | 0.023±0.001 | 2 |
| " | " | " (f) | 4.4 | 20.15 | 2958±19 | 20.6±1.2 | | 2 |
| 1-27-53 | 14763 | EX-6822 | 3.0 | 21.56 | 3070±15 | 21.5±0.8(g) 22.3±0.2(h) 22.2±0.2(i) | 0.020±0.002 | 2 |
| " | " | EX-7019 | 7.7 | 17.00 | 2766±4 | 21.0±0.5(g) 20.8±0.4(h) 20.6±0.1(i) | 0.019±0.002 | 3 |
| 1-28-53 | 14763 | EX-6883 | 2.6 | 21.28 | 3063±8 | 21.6±0.7(g) 21.7±0.4(h) 22.5±0.5(i) | 0.020±0.002(j) | 5 |
| 2-2-53 | 16078 | EX-6883 | 3.0(k) | 21.31 | 3084±5 | 22.9±0.4 | 0.019±0.002 | 5 |
| " | " | EX-6822 | 3.20(k) | 21.56 | 3093±5 | 23.5±0.5 | 0.018±0.002 | 5 |

(a) 78/22 blend of EX-7020 and EX-7019
 (b) Graphited
 (c) Ex-23-1 projectile
 (d) 800 grams of black powder in primer
 (e) 600 " " " " "
 (f) 400 " " " " "
 (g) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges.

(h) MI-2 - Dynamic calibration pressure for 1/6 sq. in area gauges
 (i) MI-3 - Dynamic calibration pressure for 1/30 sq. in area gauges
 (j) Based on 3 rounds
 (k) Cone crimp assembly

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b. Charge Determination:

(1) 5"/54 caliber guns (as indicated)
 Firing conditions were the same as the Uniformity Firings.

| <u>Date</u> | <u>Powder</u> | <u>PPD (in.)</u> (d) | <u>Gun No.</u> | <u>Mk-Mod</u> | <u>Velocity (f/s)</u> | <u>Charge (lbs.)</u> (e) | <u>Pressure (t.s.i.)</u> | <u>Remarks</u> |
|-------------|---------------|-----------------------------|--------------------|---------------|---------------------------|---------------------------------|------------------------------|----------------|
| 12-13-52 | EX-7016 | 4.2 | 16076 | 18 0 | 3000 | 20.11 | 26.3 | Too fast |
| " | " | 2.8 | " | " " | 3100 | 21.18 | 29.5(a) | Too fast |
| " | EX-7017 | 1.2 | " | " " | 3000 | 21.55 | 19.4 | Too slow |
| " | " | -0.3(e) | " | " " | 3100 | 22.53 | 21.6 | Too slow |
| " | EX-7018 | -2.0(e) | " | " " | 3000 | 23.89 | 18.4 | Too slow |
| " | " | -3.6(e) | " | " " | 3100 | 24.96 | 19.9 | Too slow |
| " | EX-7019 | 5.5 | " | " " | 3000 | 19.16 | 29.2(a) | Too fast |
| " | " | 4.1 | " | " " | 3100 | 20.10 | 32.3(a) | Too fast |
| " | EX-7020 | 2.0 | " | " " | 3000 | 20.86 | 20.1 | Too slow |
| " | " | 0.5 | " | " " | 3100 | 21.83 | 21.9 | Too slow |
| " | EX-7021 | -0.6(e) | " | " " | 3000 | 23.03 | 17.5 | Too slow |
| " | " | -2.3(e) | " | " " | 3100 | 23.98 | 18.7 | Too slow |
| " | Blend (b) | 3.5 | " | " " | 3000 | 20.47 | 21.2 | Too slow |
| " | " | 2.2 | " | " " | 3100 | 21.40 | 23.6 | (f) |
| " | EX-7038 | 2.9 | " | " " | 3000 | 21.49 | 19.6 | Too slow |
| " | " | 1.4 | " | " " | 3100 | 22.51 | 21.2 | Too slow |
| " | EX-7048 | 6.7 | " | " " | 3000 | 19.35 | (c) | Too fast |
| " | " | 5.3 | " | " " | 3100 | 20.26 | (c) | Too fast |
| " | EX-7049 | 4.9 | " | " " | 3000 | 21.06 | (c) | Too fast |
| " | " | 3.7 | " | " " | 3100 | 21.98 | (c) | Too fast |
| " | EX-7050 | 3.8 | " | " " | 3000 | 22.15 | (c) | Too fast |
| " | " | 2.5 | " | " " | 3100 | 23.12 | (c) | Too fast |
| 12-19-52 | EX-7020 | 2.1 | 14763 | 16 0 | 3000 | 20.74 | 21.0 | Too slow |
| " | " | 0.7 | " | " " | 3100 | 21.72 | 23.0 | (f) |
| " | EX-7038 | 2.8 | " | " " | 3000 | 21.56 | 19.9 | Too slow |
| " | " | 1.3 | " | " " | 3100 | 22.65 | 21.6 | Too slow |
| " | Blend (b) | 3.6 | " | " " | 3000 | 20.43 | 21.6 | Too slow |
| " | " | 2.3 | " | " " | 3100 | 21.44 | 25.7 | Too fast |
| 1-2-53 | EX-7038 | 3.1 | 16077 | 18 0 | 3000 | 21.35 | 19.0 | Too slow |
| " | " | 1.7 | " | " " | 3100 | 22.39 | 20.4 | Too slow |
| " | EX-6822 | 5.1 | " | " " | 3000 | 20.46 | 20.5 | (h) |
| " | " | 3.7 | " | " " | 3100 | 21.56 | 22.4 | (h) |
| " | EX-6883 | 4.9 | " | " " | 3000 | 20.28 | 20.1 | (g) |
| " | " | 3.5 | " | " " | 3100 | 21.31 | 21.7 | (g) |

(a) Extrapolated value

(f) Satisfactory ballistically at

(b) Blend of 78% EX-7020 and 22% EX-7019

3100 f/s but unsatisfactory

(c) Over 30 t.s.i. by extrapolation

within PPD limits

(d) PPD without gages

(g) Evaluated separately in ref. (f)

(e) Charge too large for cartridge case

(h) Evaluated separately in ref. (i)

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

(2) None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) at 3000-3100 f/s velocity and 22-24 tsi pressure were satisfactory within 3"5 PPD limitation.

(3) Soft surfaces and to a greater or lesser degree inherent "fish-scale" surface structures were observed on propellants EX-7016 through EX-7021. Because of the above conditions, optimum powder packing conditions were somewhat difficult to establish and maintain. One of the powders (EX-7020) was coated with a layer of graphite. The PPD for a charge of 20.75 lb. of this powder ungraphited was 1"6 while the same charge with a coating of graphite was 3"1, thereby allowing for 1"5 more free space remaining in the cartridge case.

(4) EX-7038 was too slow for the 5"/54 caliber gun and was found unsatisfactory as a replacement for EX-6883.

(5) EX-7048 through EX-7050, the first mono-perforated propellants fired in the 5"/54 caliber gun, were all too fast at either 3000 or 3100 f/s velocity.

It is evident that mono-perforated propellants are readily ignitable and have possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

(6) Comparative firings between the Ex-23-1 and Mk 41-0 (60 lb. projectiles) showed no appreciable difference in ballistics.

(7) One powder from each group was fired with different amounts of ignition in the primer. The data are as follows:

| Powder Index | Charge (lbs.) | Relative Ignitability | Per Cent Nitrate Nitrogen | Ignition (grains) | Velocity (f/s) | Pressure (t.s.i.) | No. of Rds. |
|--------------|---------------|-----------------------|---------------------------|-------------------|----------------|-------------------|-------------|
| EX-7019 | 17.00 | 277 | 7.56 | 800 | 2782±3 | 24.1±0.2 | 2 |
| " | " | " | " | 600 | 2782±2 | 22.8±0.5 | 2 |
| " | " | " | " | 400 | 2766±1 | 20.5±0.1 | 2 |
| EX-7017 | 21.10 | 190 | 6.42 | 800 | 2948±3 | 19.0±0.1 | 2 |
| " | " | " | " | 600 | 2928±1 | 17.8±0.0 | 2 |
| " | " | " | " | 400 | 2915±1 | 17.1±0.1 | 2 |
| EX-6883 | 20.15 | 150 | 5.03 | 800 | 2957±4 | 20.0±0.3 | 2 |
| " | " | " | " | 600 | 2949±2 | 19.9±0.2 | 2 |
| " | " | " | " | 400(a) | 2958±19 | 20.6±1.2 | 2 |

(a) 5 second hangfires

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

From the above results it can be seen that a propellant with a higher relative ignitability and higher percent nitrate nitrogen content is more sensitive to ignition changes.

Tests are currently being conducted on these propellants to determine ignition changes on pressure-time behavior and will be reported separately under "Case Gun Ignition" Task Assignment NPG-Re2a-184-1-53.

c. Pressure-Time Records:

(1) The pressure-time records obtained in the subject tests are presented in Appendix (B).

(2) EX-6822 and EX-6883 gave smooth pressure-time curves.

(3) The pressure-time curves obtained with EX-7038 had only slight steps occurring in the pressure-rise portion of the curves.

(4) EX-7020 (ungraphited) gave fairly pronounced steps in the pressure-rise region and were generally better than those obtained with EX-7020 after graphiting.

(5) Very large steps and rough peaks were obtained with EX-7019 and EX-7050.

(6) In general, none of the subject powders tested in the 5"/54 caliber gun gave as smooth pressure-time curves as either EX-6822 or EX-6883.

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

PART D

CONCLUSIONS

9. From the results of the subject tests, it is concluded that:

a. None of the subject propellants tested in the 5"/54 caliber gun (Mk 18 or Mk 16) were satisfactory at 3000-3100 f/s velocity in the 22-24 t.s.i. pressure range within the limitation of 3"5 PPD (Production Packing Depth).

b. Difficulty in establishing and maintaining optimum powder packing conditions was experienced due to the soft and fish-scale surface structures of EX-7016 through EX-7021. For the assessed charge of 20.75 lb. of EX-7020, an increase of 1"5 in PPD was obtained by graphiting the powder.

c. EX-7038 was unsatisfactory as a replacement for EX-6883.

d. Mono-perforated powders are readily ignitable and show possibilities for use at higher velocities and pressures in the 5"/54 caliber gun.

e. No appreciable differences in ballistics were obtained between the Ex-23-1 and Mk 41-0 (60 lb.) projectiles.

Preliminary firings indicate that propellants with higher relative ignitability and larger percent nitrate nitrogen are more sensitive to basic ignition changes.

f. The pressure-time curves obtained with the subject propellants had steps occurring in the pressure-rise region and in general were rougher than those obtained with EX-6822 or EX-6883.

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NPG REPORT NO. 1150

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

The tests upon which this report is based were conducted by:

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This report was prepared by:

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By direction

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NPG REPORT NO. 1150

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

8th Partial Report

on

Development of a Cool Propellant
for the 5"/54 Caliber Gun

Final Report

on

Ballistic Test of Cool Propellants
EX-7016 - EX-7021 inclusive, EX-7038, and
EX-7048 - EX-7050 inclusiveProject No.: NPG-Re2d-61-1-53
Copy No.: 11
No. of Pages: 13

Date:

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NPG REPORT NO. 1150

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA

Gun: 5"/54 Caliber, Mk 18-0 No. 16076
ESR = 42.4 D_o = 5.010
Mk 16-0 No. 14763
ESR = 180.5 D_o = 5.056
Mk 16-0 No. 14758
ESR = 296.8 D_o = 5.074
Mk 18-0 No. 16077
ESR = 54.2 D_o = 5.006
Mk 18-0 No. 16078
ESR = 271.7 D_o = 5.011

Projectile: Mk 41-0 (60.00 lb.) Empty

Cartridge Case: Mk 7

Primer: Mk 45 (XC-M5B)

Lead Foil: None

Powder: As indicated

Plug: Cork

Crimp: Cone on 2/2/53 - None on rest

Wad and Spacer: Cardboard, NGF Dwg. No. 132664
Pc. Nos. 18 and 15 (as required)

Powder Temp.: 90°F

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7060 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952

| Rd. No. | Powder (in.) | PPD (in.) | Charge (lbs.) | Velocity (f/s) | Pressure (t.s.i.) | Eject. Time (sec.) | Flash (%) | Smoke (%) |
|--------------------------------|-----------------|--------------|------------------|-------------------|----------------------|-----------------------|--------------|--------------|
| 1 - 6 (Reported separately) | | | 20.15 | 2977 | 20.4 | 0.022 | Tr | 150 |
| (a) 7 EX-6833 | 4.6 | " | " | 2970 | 20.3 | 0.019 | 75 | 125 |
| 8 | " | " | " | 2970 | 20.0 | 0.022 | 0 | 150 |
| 9 | " | " | " | 2972 | 19.9 | 0.021 | 0 | 150 |
| 10 | " | " | " | 2976 | 20.0 | 0.019 | 75 | 125 |
| 11 | " | " | " | 2967 | 19.9 | 0.022 | 0 | 150 |
| 12 | " | " | " | 2971±2 | 20.0±0.1 | 0.021±0.001 | | |
| Mean of 5 rounds | | | 20.15 | | | | | |
| 13 EX-7016 | 8.1 | 17.00 | 2694 | 18.3 | 0.017 | 0 | 150 | |
| 14 | 6.0 | 18.50 | 2850 | 21.2 | 0.018 | 0 | 150 | |
| 15 | " | " | 2850 | 21.8 | 0.017 | 0 | 150 | |
| Mean of 2 rounds | | | 18.50 | 2850±0 | 21.5±0.3 | 0.018±0.001 | | |
| 16 EX-7016 | 3.8 | 20.00 | 2990 | 25.9 | 0.017 | 0 | 150 | |
| 17 EX-7017 | 5.1 | 18.50 | 2693 | 14.4 | 0.019 | 75 | 125 | |
| 18 | " | " | 2695 | 14.1 | 0.019 | 75 | 125 | |
| Mean of 2 rounds | | | 18.50 | 2689±4 | 14.3±0.2 | 0.019±0.000 | | |
| 19 EX-7017 | 2.2 | 20.50 | 2879 | 17.2 | 0.021 | 75 | 125 | |
| 20 | 1.4 | 21.10 | 2955 | 18.3 | 0.017 | 75 | 125 | |
| 21 | " | " | 2954 | 18.2 | 0.019 | 75 | 125 | |
| 22 | " | " | 2956 | 18.7 | 0.020 | 75 | 125 | |
| Mean of 3 rounds | | | 21.10 | 2954±1 | 18.4±0.2 | 0.019±0.001 | | |
| 23 EX-7018 | 3.1 | 20.00 | 2645 | 13.1 | 0.022 | 75 | 125 | |
| 24 | " | " | 2629 | 12.6 | 0.021 | 75 | 125 | |
| Mean of 2 rounds | | | 20.00 | 2637±8 | 12.9±0.5 | 0.022±0.001 | | |

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7338, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 13 December 1952 (Continued)

| Rd. No. | Powder | PPD (in.) | Charge (lbs.) | Velocity (f/s) | Pressure (t.s.i.) | Eject. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|---------|--------------|------------------|-------------------|----------------------|-----------------------|--------------|--------------|
| 25 | EX-7018 | 1.4 | 21.20 | 2749 | 14.6 | 0.020 | 100 | 100 |
| 26 | EX-7019 | 8.1 | 17.00 | 2777 | 20.7 | 0.020 | 75 | 125 |
| 27 | " | 5.9 | 18.50 | 2927 | 27.0 | 0.016 | 0 | 150 |
| 28 | " | " | " | 2932 | 26.2 | 0.017 | 75 | 125 |
| Mean of 2 rounds | | 18.50 | 2930±3 | 26.6±0.4 | 0.017±0.001 | | | |
| 29 | EX-7019 | 4.5 | 19.50 | 3036 | - | 0.016 | 75 | 125 |
| 30 | EX-7020 | 6.4 | 17.50 | 2644 | 13.9 | 0.020 | 0 | 150 |
| 31 | " | 4.9 | 18.50 | 2753 | 15.6 | 0.021 | 100 | 100 |
| 32 | " | " | " | 2761 | 15.9 | 0.018 | 100 | 100 |
| Mean of 2 rounds | | 18.50 | 2757±4 | 15.8±0.2 | 0.020±0.002 | | | |
| 33 | EX-7020 | 1.4 | 20.90 | 2998 | 20.3 | 0.016 | 100 | 100 |
| 34 | " | " | " | 3009 | 20.1 | 0.017 | 100 | 100 |
| Mean of 2 rounds | | 20.90 | 3004±6 | 20.2±0.1 | 0.017±0.001 | | | |
| 35 | EX-7021 | 4.6 | 19.00 | 2588 | 12.5 | 0.019 | 100 | 100 |
| 36 | " | " | " | 2570 | 12.3 | 0.019 | 100 | 100 |
| Mean of 2 rounds | | 19.00 | 2579±9 | 12.4±0.1 | 0.019±0.000 | | | |
| 37 | EX-7021 | 1.4 | 21.20 | 2813 | 15.8 | 0.020 | 100 | 100 |
| 38 | " | " | " | 2805 | 15.1 | 0.021 | 100 | 100 |
| Mean of 2 rounds | | 21.20 | 2809±4 | 15.2±0.1 | 0.021±0.001 | | | |

Ballistic Test of Cool Propellants EX-7018 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 15 December 1952 (Continued)

| Rd. No. | PFD (in.) | Charge (lbs.) | Velocity (f/s) | Pressure (t.s.i.) | Ejcc. Time (sec.) | Flash (%) | Smoke (%) |
|------------|------------------|------------------|-------------------|----------------------|----------------------|--------------|--------------|
| 39 | EX-7020 | 5.7 | 16.00 | 2730 | 15.7 | 0.020 | 100 |
| | EX-7019 | 4.2 | 16.00 | 2844 | 18.5 | 0.017 | 100 |
| 40 | " | 2.7 | 16.00 | 2945 | 19.6 | 0.019 | 100 |
| 41 | " | 4.0 | 16.00 | 3059 | 23.0 | 0.017 | 100 |
| 42 | " | 1.4 | 16.00 | 5.00 | 12.6 | 0.019 | 100 |
| 43 | EX-7038 | 8.6 | 17.00 | 2555 | 14.1 | 0.021 | 100 |
| 44 | " | 7.2 | 18.00 | 2656 | 14.3 | 0.019 | 100 |
| 45 | " | " | " | 2661 | 14.1 | 0.022 | 100 |
| 46 | " | " | " | 2659±2 | 14.2±0.1 | 0.021±0.001 | 100 |
| | Mean of 3 rounds | 18.00 | | | | | |
| 47 | EX-7038 | 4.4 | 20.00 | 2841 | 16.2 | 0.021 | 100 |
| 48 | " | 1.4 | 22.20 | 3065 | 20.9 | 0.019 | 100 |
| 49 | " | " | " | 3071 | 20.5 | 0.017 | 100 |
| 50 | " | " | " | 3075 | 20.9 | 0.017 | 100 |
| | Mean of 3 rounds | 22.20 | | 3070±4 | 20.7±0.3 | 0.018±0.001 | |
| 51 | EX-7048 | 10.9 | 16.00 | 2644 | - | 0.016 | 0 |
| 52 | " | 9.5 | 17.00 | 2747 | - | 0.015 | 0 |
| 53 | " | 15.4 | 13.00 | 2324 | 17.3 | 0.018 | 0 |
| 54 | " | 13.7 | 14.00 | 2429 | 19.9 | 0.017 | 0 |
| 55 | " | 12.3 | 15.00 | 2549 | - | 0.020 | 0 |
| 56 | EX-7049 | 12.7 | 15.00 | 2361 | 14.0 | 0.018 | 75 |
| 57 | " | 11.4 | 16.00 | 2474 | 17.5 | 0.021 | 75 |
| 58 | " | 10.0 | 17.00 | 2570 | 20.9 | 0.021 | 75 |
| 59 | " | 9.3 | 17.50 | 2624 | 22.9 | 0.018 | 75 |
| 60 | EX-7050 | 1.3 | 16.00 | 2387 | 14.0 | 0.018 | 75 |
| 61 | " | 10.0 | 17.00 | 2494 | 16.8 | 0.018 | 0 |
| 62 | " | 8.6 | 18.00 | 2588 | 18.8 | 0.016 | 100 |
| 55 | " | 6.7 | 19.50 | 2736 | 23.2 | 0.016 | 100 |

(a) Conditioning round.

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952

| | | | | Gun: Mk 16-0, No. 14763 | | | |
|------------------|---------|-----------------------|-------|------------------------------------|----------|-------------|-------------|
| | | | | ESR = 180.5 D ₀ = 5.056 | | | |
| Rd. | No. | Powder | PPD | Charge | Velocity | Pressure | Smoke |
| (a) 7 - 6 | | (Reported separately) | | 20.15 | 3007 | 21.4 | 0.019 |
| (a) 7 | 7 | EX-6883 | 4.6 | " | 2983 | 20.6 | 0.019 |
| | 8 | " | " | " | 2994 | 21.7 | - |
| | 9 | " | " | " | 2990 | 20.5 | 0.019 |
| | 10 | " | " | " | 3004 | 21.5 | 0.018 |
| | 11 | " | " | " | 2979 | 20.4 | 0.019 |
| | 12 | " | " | " | 2990±7 | 20.9±0.5 | 0.019±0.000 |
| Mean of 5 rounds | | 20.15 | | 2990±7 | | 0.019±0.000 | |
| 13 | EX-7020 | 4.9 | 18.50 | 2776 | 16.7 | 0.017 | 100 |
| 14 | " | " | " | 2774 | 16.4 | 0.018 | 0 |
| 15 | " | " | " | 2764 | 16.1 | 0.020 | 0 |
| Mean of 3 rounds | | 18.50 | | 2771±5 | | 0.018±0.001 | |
| 16 | EX-7020 | 1.6 | 20.75 | 3001 | 20.7 | 0.019 | 100 |
| 17 | " | " | " | 2993 | 20.7 | 0.016 | 100 |
| 18 | " | " | " | 3002 | 21.2 | 0.017 | 100 |
| 19 | " | " | " | 3005 | 21.1 | 0.017 | 100 |
| 20 | " | " | " | 3004 | 21.1 | 0.018 | 100 |
| Mean of 5 rounds | | 20.75 | | 3001±3 | | 0.017±0.001 | |
| 21 | EX-7020 | 1.4 | 20.90 | 3010 | 20.8 | 0.016 | 100 |
| 22 | EX-7038 | 7.2 | 18.00 | 2674 | 14.2 | 0.022 | 0 |
| 23 | " | " | " | 2672 | 14.5 | 0.020 | 25 |
| 24 | " | " | " | 2675 | 14.4 | 0.021 | 0 |
| Mean of 3 rounds | | 18.00 | | 2674±1 | | 0.021±0.001 | |
| 25 | EX-7038 | 2.3 | 21.50 | 2977 | 19.3 | 0.020 | 100 |
| 26 | " | 1.4 | 22.20 | 3070 | 21.1 | 0.018 | 100 |
| 27 | " | " | " | 3049 | 20.7 | 0.019 | 100 |
| 28 | " | " | " | 3062 | 21.1 | 0.017 | 100 |
| 29 | " | " | " | 3059 | 21.1 | 0.017 | 100 |
| 30 | " | " | " | 3057 | 20.5 | 0.018 | 100 |
| Mean of 5 rounds | | 22.20 | | 3059±5 | | 0.018±0.001 | |

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952 (Continued)

| Rd. No. | Powder | PPD (in.) | Charge (lbs.) | Velocity (ft/s.) | Pressure (t.s.i.) | Eject. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|--------------------|--------------|------------------|---------------------|----------------------|-----------------------|--------------|--------------|
| 31 | EX-7020 EX-7019 | 2.0 | 16.00 4.50 | 2998 | 22.0 | 0.017 | 100 | 100 |
| 32 | " | " | " | 3012 | 22.1 | 0.016 | 100 | 100 |
| 33 | " | " | " | 2998 | 22.0 | 0.016 | 100 | 100 |
| 34 | " | " | " | 3011 | 21.0 | 0.016 | 100 | 100 |
| 35 | " | " | " | 3017 | 22.0 | 0.017 | 100 | 100 |
| Mean of 5 rounds | | | | 3007±7 | 21.8±0.3 | 0.016±0.000 | | |
| 36 | EX-7020 EX-7019 | 1.4 | 16.39 4.61 | 3049 | 23.5 | 0.016 | 100 | 100 |
| 37 | " | 5.7 | 14.05 3.95 | 2759 | 16.6 | 0.018 | 0 | 150 |
| 38 | " | " | " | 2762 | 16.8 | 0.016 | 0 | 150 |
| 39 | " | " | " | 2757 | 17.0 | 0.020 | 0 | 150 |
| Mean of 3 rounds | | | | 2759±2 | 16.8±0.1 | 0.018±0.001 | | |
| 40 | EX-7020 (b) | 2.6 | 20.75 | 2978 | 22.5 | 0.019 | 100 | 100 |
| 41 | " | 2.0 | 21.50 | 3065 | 25.0 | 0.016 | 100 | 100 |
| 42 | " | 3.1 | 20.75 | 2983 | 21.0 | 0.016 | 100 | 100 |
| 43 | " | " | " | 2982 | 21.4 | 0.018 | 100 | 100 |
| 44 | " | " | " | 2972 | 21.2 | 0.016 | 100 | 100 |
| Mean of 3 rounds | | | | 2979±5 | 21.2±0.1 | 0.017±0.001 | | |

(a) Conditioning round
(b) Graphited

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 19 December 1952

| Rd. | No. | Powder | PPD | Charge | Velocity | Pressure | Ejec. Time | Flash | Smoke | | | | | | |
|------------------|-----|-------------|-------|--------|----------|----------|-------------|-------|-------|--|--|--|--|--|--|
| (a) | | | (in.) | (lbs.) | (ft/s) | (t.s.i.) | (sec.) | (%) | (%) | | | | | | |
| 1 | | EX-6883 | 6.9 | 18.50 | 2730 | 16.4 | -- | 0 | 175 | | | | | | |
| 2 | " | " | 4.6 | 2C.15 | 2940 | 18.8 | 0.020 | 75 | 125 | | | | | | |
| 3 | " | " | " | " | 2941 | 18.5 | 0.018 | Tr | 150 | | | | | | |
| 4 | " | " | " | " | 2940 | 18.4 | 0.021 | Tr | 150 | | | | | | |
| Mean of 3 rounds | | | | 20.15 | 2940±0 | 18.6±0.2 | 0.020±0.001 | | | | | | | | |
| 5 | | EX-7020 | 1.6 | 20.75 | 2955 | 19.9 | 0.019 | 100 | 100 | | | | | | |
| 6 | " | " | " | " | 2958 | 19.6 | 0.016 | 100 | 100 | | | | | | |
| 7 | " | " | " | " | 2962 | 19.4 | 0.018 | 100 | 100 | | | | | | |
| Mean of 3 rounds | | | | 20.75 | 2958±2 | 19.6±0.2 | 0.018±0.001 | | | | | | | | |
| 8 | | EX-7038 | 2.5 | 21.50 | 2949 | 18.7 | 0.018 | 100 | 100 | | | | | | |
| 9 | " | " | " | " | 2968 | 18.3 | 0.017 | 100 | 100 | | | | | | |
| 10 | " | " | " | " | 2963 | 18.7 | 0.017 | 100 | 100 | | | | | | |
| Mean of 3 rounds | | | | 21.50 | 2960±7 | 18.6±0.2 | 0.017±0.000 | | | | | | | | |
| 11 | | EX-7020 | 2.0 | 16.00 | 2975 | 21.4 | 0.017 | 100 | 100 | | | | | | |
| 12 | " | EX-7019 (b) | " | 4.50 | 2981 | 22.0 | 0.016 | 100 | 100 | | | | | | |
| 13 | " | " | " | " | 2968 | 21.4 | 0.017±0.001 | 100 | 100 | | | | | | |
| Mean of 3 rounds | | | | 16.00 | 2975±4 | 16.6±0.5 | 0.017±0.001 | | | | | | | | |
| 14 | | EX-7050 | 7.8 | 18.65 | 2642 | 21.1 | 0.016 | 80 | 125 | | | | | | |
| 15 | " | " | " | " | 2645 | 21.8 | 0.019 | 80 | 125 | | | | | | |
| 16 | " | " | " | " | 2644 | 21.2 | 0.016 | 80 | 125 | | | | | | |
| Mean of 3 rounds | | | | 18.65 | 2644±1 | 21.4±0.3 | 0.017±0.001 | | | | | | | | |
| 17 | | EX-7020 (c) | 3.1 | 20.75 | 2963 | 20.7 | 0.016 | 100 | 100 | | | | | | |
| 18 | " | " | " | " | 2957 | 20.8 | 0.017 | 100 | 100 | | | | | | |
| 19 | " | " | " | " | 2956 | 22.3 | 0.017 | 100 | 100 | | | | | | |
| Mean of 3 rounds | | | | 20.75 | 2959±5 | 21.3±0.7 | 0.017±0.000 | | | | | | | | |

(a) Conditioning round (b) 78/22 blend (c) Graphited

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 January 1953

| Rd. No. | Powder (Reported separately) | PPD (in.) | Charge (lbs.) | Velocity (f/s) | Pressure (t.s.i.) | Ejec. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|------------------------------------|--------------|------------------|-------------------|----------------------|----------------------|--------------|--------------|
| 1 - 6 | | | | | | | | |
| (a) 7 | EX-7038 | 6.7 | 18.50 | 2732 | 15.4 | 0.011 | 50 | 100 |
| 8 | " | " | " | 2727 | 15.1 | 0.018 | 50 | 100 |
| 9 | " | " | " | 2723 | 15.1 | 0.019 | 0 | 150 |
| Mean of 2 rounds | | 18.50 | 2725±2 | 15.1±0.0 | 0.019±0.001 | | | |
| 10 | EX-7038 | 3.0 | 21.00 | 2971 | 18.3 | 0.018 | 100 | 100 |
| 11 | " | " | " | 2960 | 18.7 | 0.020 | 100 | 100 |
| 12 | " | " | " | 2968 | 18.8 | 0.018 | 100 | 100 |
| 13 | " | " | " | 2965 | 18.2 | 0.017 | 100 | 100 |
| Mean of 4 rounds | | 21.00 | 2966±4 | 18.5±0.3 | 0.018±0.001 | | | |
| 14 | EX-7038 (b) | 3.0 | 21.00 | 2971 | 18.8 | 0.018 | 100 | 100 |
| 15 | " | " | " | 2949 | 17.4 | 0.018 | 0 | 150 |
| 16 | " | " | " | 2967 | 17.7 | 0.021 | 0 | 150 |
| 17 | " | " | " | 2967 | 17.9 | 0.019 | 100 | 100 |
| 18 | " | " | " | 2947 | 18.0 | 0.022 | 100 | 100 |
| Mean of 5 rounds | | 21.00 | 2960±1.0 | 17.8±0.4 | 0.020±0.002 | | | |
| 19 | EX-6822 | 7.3 | 18.50 | 2829 | 18.0 | 0.019 | 0 | 150 |
| 20 | " | " | " | 2817 | 17.5 | 0.022 | 25 | 100 |
| 21 | " | " | " | 2821 | 16.9 | 0.025 | 25 | 100 |
| Mean of 3 rounds | | 18.50 | 2822±4 | 17.5±0.4 | 0.022±0.002 | | | |
| 22 | EX-6822 | 5.0 | 20.20 | 2981 | 19.8 | 0.018 | 0 | 150 |
| 23 | " | 3.9 | 21.00 | 3056 | 21.9 | 0.017 | 0 | 150 |
| 24 | " | 3.5 | 21.30 | 3082 | 22.3 | 0.021 | Tr | 150 |
| 25 | " | " | " | 3080 | 21.6 | 0.018 | Tr | 150 |
| 26 | " | " | " | 3071 | 21.7 | 0.018 | Tr | 150 |
| 27 | " | " | " | 3069 | 22.0 | 0.017 | Tr | 150 |
| 28 | " | " | " | 3079 | 22.0 | 0.019 | Tr | 150 |
| Mean of 5 rounds | | 21.30 | 3076±5 | 22.0±0.2 | 0.019±0.001 | | | |

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 January 1953 (Continued)

| Rd. No. | Powder EX-6822 (b) | PPD (in.) | Charge (lbs.) | Velocity (f/s) | Pressure (t.s.i.) | Ejec. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|-----------------------|--------------|------------------|-------------------|----------------------|----------------------|--------------|--------------|
| 29 | " | 3.5 | 21.30 | 3084 | 22.5 | 0.020 | Tr | 150 |
| 30 | " | " | " | 3064 | 21.7 | 0.021 | Tr | 150 |
| 31 | " | " | " | 3071 | 21.6 | 0.018 | Tr | 150 |
| 32 | " | " | " | 3081 | 21.6 | 0.021 | 100 | 100 |
| 33 | " | " | " | 3080 | 21.4 | 0.017 | 100 | 100 |
| Mean of 5 rounds | | 21.30 | 3076±7 | 21.8±0.3 | 0.019±0.002 | | | |
| 34 | EX-6822 | 3.2 | 21.50 | 3099 | 23.6 | 0.018 | Tr | 150 |
| 35 | EX-6883 | 6.9 | 18.50 | 2833 | 17.3 | 0.020 | 0 | 150 |
| 36 | " | " | " | 2818 | 16.9 | 0.019 | 50 | 100 |
| 37 | " | " | " | 2828 | 17.5 | 0.020 | 0 | 150 |
| Mean of 3 rounds | | 18.50 | 2826±6 | 17.2±0.2 | 0.020±0.000 | | | |
| 38 | EX-6883 | 4.7 | 20.15 | 2982 | 20.2 | 0.019 | 100 | 100 |
| 39 | " | 3.4 | 21.00 | 3062 | 21.1 | 0.021 | 100 | 100 |
| 40 | " | 3.0 | 21.30 | 3101 | 21.3 | 0.021 | Tr | 150 |
| 41 | " | " | " | 3096 | 21.1 | 0.018 | 100 | 100 |
| 42 | " | " | " | 3105 | 21.9 | 0.018 | Tr | 150 |
| 43 | " | " | " | 3094 | 22.6 | 0.021 | Tr | 150 |
| 44 | " | " | " | 3099 | 21.4 | 0.018 | 100 | 100 |
| Mean of 5 rounds | | 21.30 | 3099±3 | 21.7±0.5 | 0.019±0.001 | | | |
| 45 | EX-6883 (b) | 5.0 | 21.30 | 3102 | 22.1 | 0.021 | Tr | 150 |
| 46 | " | " | " | 3104 | 21.7 | 0.018 | 100 | 100 |
| 47 | " | " | " | 3101 | 21.8 | 0.018 | Tr | 150 |
| 48 | " | " | " | 3098 | 22.5 | 0.019 | 100 | 100 |
| 49 | " | " | " | 3103 | 21.3 | 0.018 | 100 | 100 |
| Mean of 5 rounds | | 21.30 | 3102±0.3 | 21.9±0.3 | 0.019±0.001 | | | |
| 50 | EX-6883 | 6.9 | 18.50 | 2830 | 17.2 | 0.019 | 100 | 100 |

(a) Conditioning round
(b) Ex-23-1 projectileCONFIDENTIAL
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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 22 January 1953

| Exd. No. | Powder P.D. (in.) | Charge (lbs.) | Velocity (ft/s.) | Pressure (t.s.i.) | Eject. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|-------------------------|------------------|---------------------|----------------------|-----------------------|--------------|--------------|
| (a) 1 | EX-7019 (d) | 8.1 | 17.00 | 2705 | 21.0 | 0.017 | 200 |
| 2 | " | " | " | 2779 | 23.9 | 0.018 | 150 |
| 3 | " | " | " | 2784 | 24.2 | 0.019 | 0 |
| Mean of 2 rounds | | 17.00 | 2782±3 | 24.1±0.2 | 0.019±0.001 | 0 | 150 |
| 4 | EX-7019 (e) | 8.1 | 17.00 | 2780 | 22.5 | 0.019 | 0 |
| 5 | " | " | " | 2783 | 23.2 | 0.018 | 0 |
| Mean of 2 rounds | | 17.00 | 2782±2 | 22.8±0.5 | 0.019±0.001 | 0 | 150 |
| 6 | EX-7019 (f) | 8.1 | 17.00 | 2765 | 20.5 | 0.018 | 0 |
| 7 | " | " | " | 2767 | 20.4 | 0.021 | 0 |
| Mean of 2 rounds | | 17.00 | 2766±1 | 20.5±0.1 | 0.020±0.002 | 0 | 150 |
| 8 | EX-7017 (d) | 1.4 | 21.10 | 2945 | 18.9 | 0.019 | 100 |
| 9 | " | " | " | 2951 | 19.1 | 0.018 | 100 |
| Mean of 2 rounds | | 21.10 | 2948±3 | 19.0±0.1 | 0.019±0.001 | 0 | 100 |
| 10 | EX-7017 (e) | 1.4 | 21.10 | 2929 | 17.8 | 0.018 | 100 |
| 11 | " | " | " | 2927 | 17.8 | 0.019 | 100 |
| Mean of 2 rounds | | 21.10 | 2928±1 | 17.8±0.0 | 0.019±0.001 | 0 | 100 |
| 12 | EX-7017 (f) | 1.4 | 21.10 | 2915 | 17.0 | 0.019 | 100 |
| 13 | " | " | " | 2914 | 17.2 | 0.019 | 100 |
| Mean of 2 rounds | | 21.10 | 2915±1 | 17.1±0.1 | 0.019±0.000 | 0 | 100 |

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 22 January 1953 (contimed)

| Rd. No. | Powder (1 in.) | Charge (1 lbs.) | Velocity (ft/s.) | Pressure (t.s.i.) | Eject. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|-------------------|--------------------|---------------------|------------------------------|-----------------------|--------------|--------------|
| 14 | EX-6883 (d) | 4.4 | 20.15 | 2965 | 19.3 (b) 19.7 (c) | 0.023 | 100 |
| 15 | " | " | " | 2959 | — | 0.021 | 100 |
| 16 | " | " | " | 2953 | 19.3 (b) 19.6 (c) | 0.021 | 100 |
| 17 | " | " | " | 2950 | 19.2 (b) 20.0 (c) | 0.021 | 100 |
| 18 | " | " | " | 2957 | 19.1 (b) 20.8 (c) | 0.020 | 100 |
| Mean of 5 rounds | | 20.15 | 2957±4 | 19.2±0.1 (b) 20.0±0.5 (c) | 0.021±0.001 | | |
| 19 | EX-6883 (e) | 4.4 | 20.15 | 2947 | 19.7 | 0.022 | 100 |
| 20 | " | " | " | 2951 | 20.0 | 0.023 | 150 |
| Mean of 2 rounds | | 20.15 | 2949±2 | 19.9±0.2 | 0.023±0.001 | 0 | |
| 21 | EX-6883 (f) | 4.4 | 20.15 | 2939 | 19.4 | — | 100 |
| 22 | " | " | " | 2976 | 21.8 | — | 100 |
| Mean of 2 rounds | | 20.15 | 2958±19 | 20.6±1.2 | | | |
| | EX-7017 | 5.1 | 18.50 | 2664 | 13.7 | 0.019 | 100 |
| | | | | | | | |

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 27 January 1955

Gun: Mk 16-0, No. 14763
ESR = 180.5 D₀ = 5.056

| Rd. No. | Powder (in.) | PPD (lbs.) | Charge (f/s) | Velocity (f/s) | Pressure (t.s.i.) (a) (t.s.i.) (b) | Pressure (t.s.i.) (c) (t.s.i.) (d) | Ejec. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|-----------------|---------------|-----------------|-------------------|--|--|----------------------|--------------|--------------|
| (a) 1 | EX-7019 | 7.7 | 17.00 | 2761 | 19.5 | 19.4 | 20.0 | 0.020 | 0 100 |
| 2 | EX-6822 | 3.0 | 21.56 | 3084 | 22.3 | 22.4 | 22.4 | 0.018 | |
| 3 | " | " | " | 3056 | 20.7 | 22.1 | 22.0 | 0.022 | |
| Mean of 2 rounds | | 21.56 | 3070±1.5 | 21.5±0.8 | 22.3±0.2 | 22.2±0.2 | 22.2±0.2 | 0.020±0.002 | |
| 4 | EX-7019 | 7.7 | 17.00 | 2763 | 20.9 | 21.0 | 20.6 | 0.019 | |
| 5 | " | " | " | 2773 | 21.7 | 21.3 | 20.5 | 0.016 | |
| 6 | " | " | " | 2763 | 20.4 | 20.2 | 20.7 | 0.022 | |
| Mean of 3 rounds | | 17.00 | 2766±4 | 21.0±0.5 | 20.8±0.4 | 20.6±0.1 | 20.6±0.1 | 0.019±0.002 | |

(a) Conditioning round
 (b) T-1070 - Static calibration pressure for 1/6 sq. in. area gauges
 (c) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges
 (d) MI-3 - Dynamic calibration pressure for 1/30 sq. in. area gauges

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 28 January 1953

Gun: Mk 16-0, No. 14763
ESR = 180.5 D₀ = 5.056

| Rd. No. | Powder | PPD (in.) | Charge (lbs.) | Velocity (f/s.) | Pressure (t.s.i.) ^(b) | Pressure (t.s.i.) ^(c) | Pressure (t.s.i.) ^(d) | Ejec. Time (sec.) | Flash (%) | Smoke (%) |
|------------------|---------|--------------|------------------|--------------------|-------------------------------------|-------------------------------------|-------------------------------------|----------------------------|--------------|--------------|
| (a) 1 | EX-7019 | 7.7 | 17.00 | 2769 | 20.6 | 21.2 | 20.6 | - | - | - |
| 2 | EX-6883 | 2.6 | 21.28 | 3052 | 20.5 | 21.2 | 21.5 | - | - | - |
| 3 | " | " | " | 3055 | 21.1 | 21.9 | 22.2 | - | - | - |
| 4 | " | " | " | 3071 | 21.6 | 21.2 | 22.7 | 0.021 | - | - |
| 5 | " | " | " | 3068 | 22.2 | 22.5 | 21.7 | 0.017 | - | - |
| 6 | " | " | " | 3070 | 22.7 | 22.0 | 23.0 | 0.021 | - | - |
| Mean of 5 rounds | | | 3063±8 | 21.6±0.7 | 21.7±0.4 | 22.2±0.5 | 22.2±0.5 | 0.020±0.002 ^(e) | | |

Conditioning round

- (a) R-1070 - Static calibration pressure for 1/6 sq. in. area gauges
- (b) MI-2 - Dynamic calibration pressure for 1/6 sq. in. area gauges
- (c) MI-3 - Dynamic calibration pressure for 1/30 sq. in. area gauges
- (d) Based on 3 rounds
- (e)

Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive, EX-7038, and EX-7048 - EX-7050 inclusive

TABULATION OF FIRING DATA (Continued)

Date: 2 February 1953

Gun: Mk 18-0, No. 16078
ESR = 271.7 D₀ = 5.011

| Rd. No. | Powder | PPD (in.) | Charge (lbs.) | Velocity (f/s) | Pressure (t.s.i.) | Ejec. Time (sec.) | | Flash (%) | Smoke (%) |
|------------------|---------|--------------|------------------|-------------------|----------------------|----------------------|-------|--------------|--------------|
| | | | | | | 0.019 | 0.017 | | |
| (a) 1 | EX-6883 | 3.0 | 21.51 | 3045 | 23.2 | | | 0 | 150 |
| 2 | " | " | " | 3084 | 23.2 | 0.017 | 100 | 100 | |
| 3 | " | " | " | 3072 | 23.0 | 0.020 | 100 | 100 | |
| 4 | " | " | " | 3088 | 22.0 | 0.021 | Tr | 150 | |
| 5 | " | " | " | 3086 | 22.7 | 0.021 | 100 | 100 | |
| 6 | " | " | " | 3091 | 23.6 | 0.017 | 75 | 125 | |
| Mean of 5 rounds | | 21.51 | 3084±5 | 22.9±0.4 | 22.9±0.002 | | | | |
| 7 | EX-6822 | 3.2 | 21.56 | 3085 | 23.7 | 0.018 | 100 | 100 | |
| 8 | " | " | " | 3094 | 23.8 | 0.020 | 100 | 100 | |
| 9 | " | " | " | 3096 | 23.9 | 0.016 | 100 | 100 | |
| 10 | " | " | " | 3100 | 22.4 | 0.016 | 100 | 100 | |
| 11 | " | " | " | 3089 | 23.8 | 0.021 | 100 | 100 | |
| Mean of 5 rounds | | 21.56 | 3093±5 | 23.5±0.5 | 23.5±0.02 | | | | |

Note: Cone crimp assembly on all rounds.

(a) Conditioning round.

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Ballistic Test of Cool Propellants EX-7016 - EX-7021 inclusive,
EX-7038, and EX-7048 - EX-7050 inclusive

PRESSURE TIME-CURVES

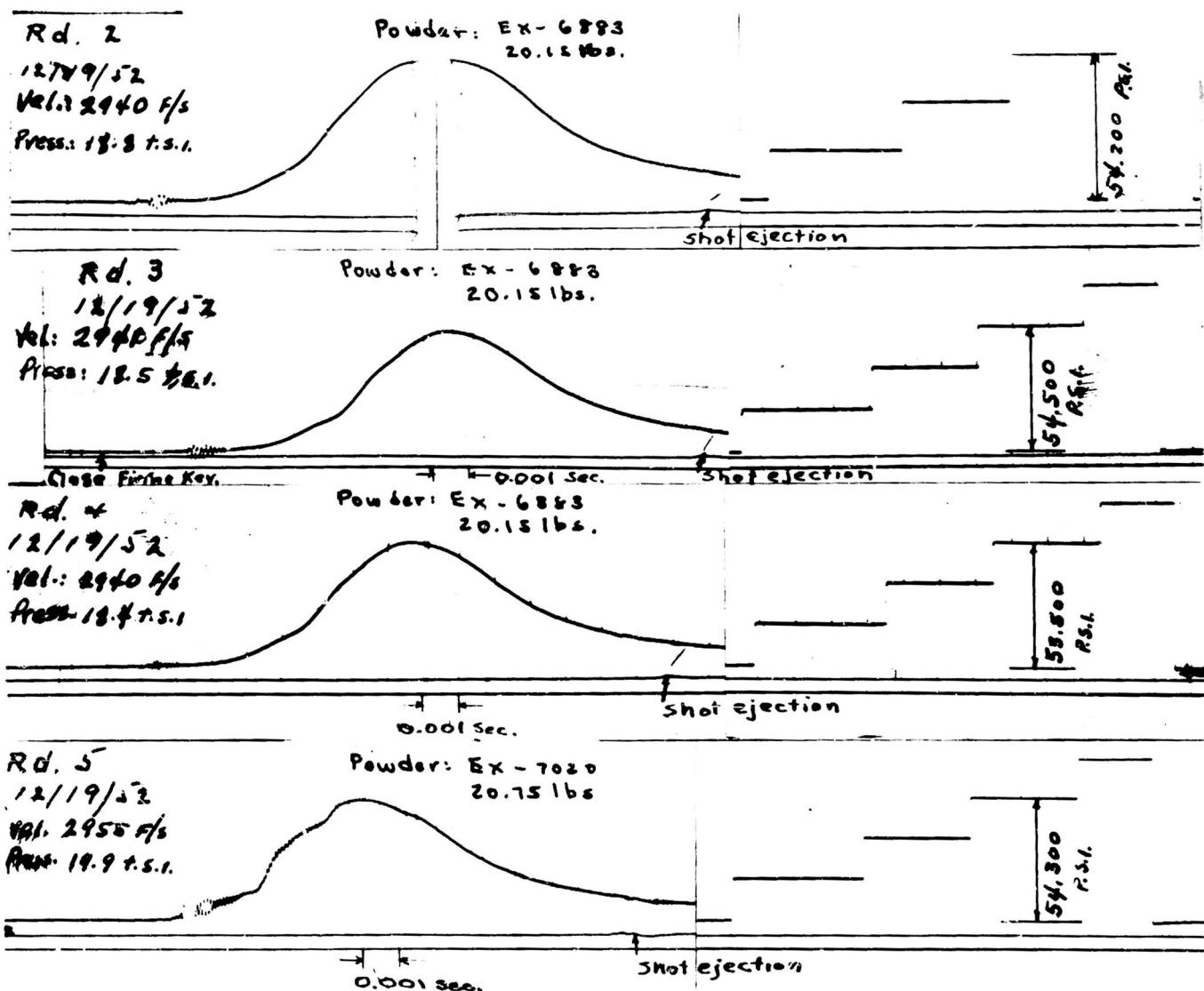
Gun: 5"/54 caliber Mk 16-0, No's. 14758 and 14763
Projectile: Mk 41-0 (60.00 lb.) Empty
Cartridge Case: Mk 7
Primer: Mk 45
Lead Foil: None
Powder: As indicated
Plug: Cork
Was and Spacer: Cardboard, NGF Dwg. 132664
Pc. Nos. 18 and 15 (as required)
Powder Temp.: 90°F

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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



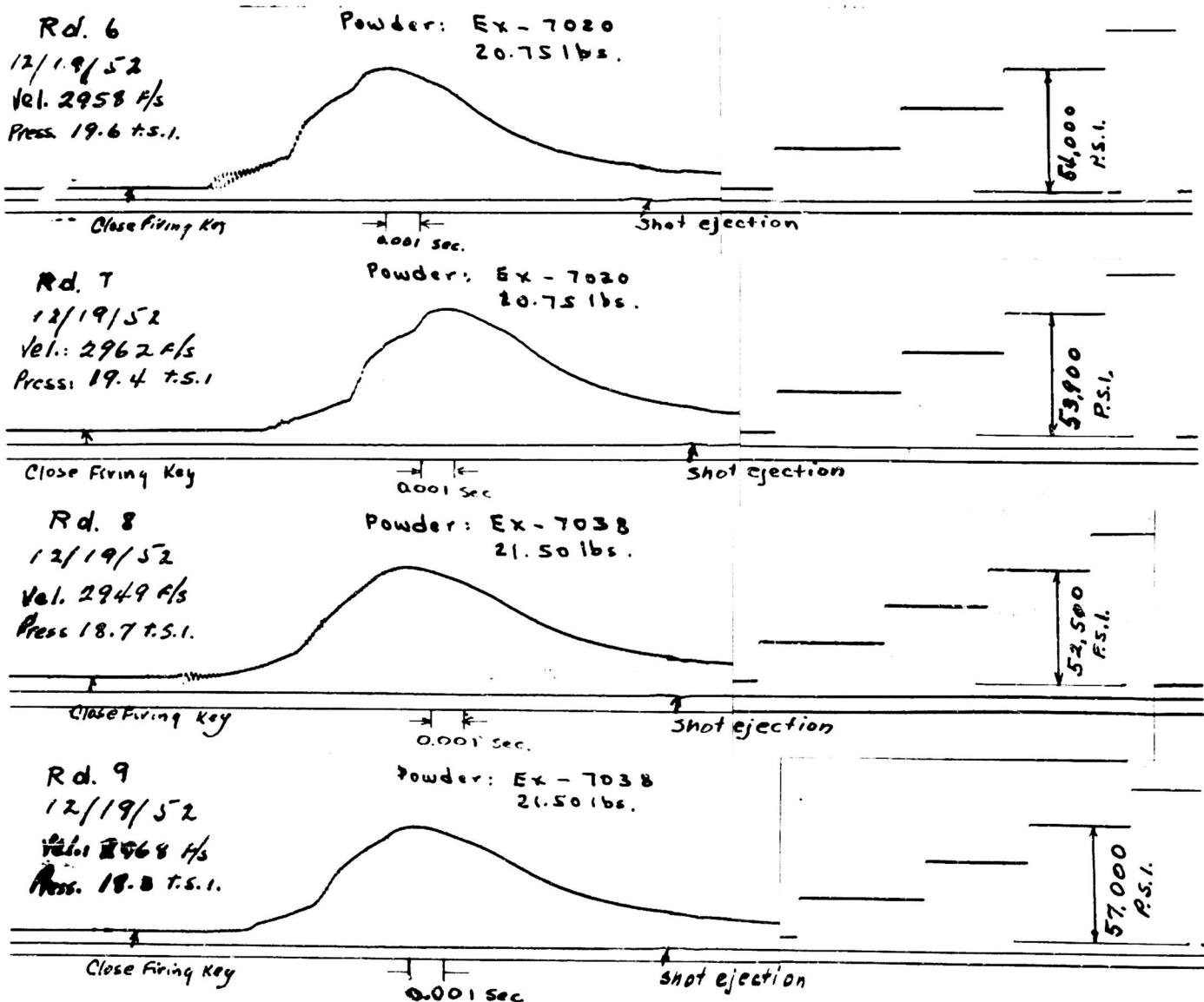
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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES



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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES

Rd. 10

12/19/52

Vel. 2463 f/s

Press. 18.7 P.S.I.

Powder: EX-7038
21.50 lbs.

0.001 sec.

54.600
P.S.I.

Rd. 11

12/19/52

Vel. 2975 f/s

Press. 21.4 P.S.I.

Powder: EX-7020 + EX-7019
16.00 lbs + 4.50 lbs.

0.001 sec.

Shot ejection

54.300
P.S.I.

Rd. 12

12/19/52

Vel. 2981 f/s

Press. 22.0 P.S.I.

Powder: EX-7020 + EX-7019
16.00 lbs + 4.50 lbs.

0.001 sec.

Shot ejection

54.900
P.S.I.

Rd. 13

12/19/52

Vel. 2968 f/s

Press. 21.4 P.S.I.

Powder: EX-7020 + EX-7019
16.00 lbs + 4.50 lbs.

0.001 sec.

Shot ejection

53.300
P.S.I.

Rd. 14

12/19/52

Vel. 2642 f/s

Press. 21.1 P.S.I.

Powder: EX-7050
18.65 lbs.

0.001 sec.

Shot ejection

54.200
P.S.I.

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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES

Rd. 15
12/19/52
Vel. 2645 f/s
Press 21.8 t.s.i.

Powder: EX-7050
18.65 lbs.

0.001 SEC
Shot ejection
Powder: EX-7050
18.65 lbs.

Rd. 16
12/19/52
Vel. 2644 f/s
Press. 21.2 t.s.i.

0.001 SEC.
Shot ejection
Powder: EX-7020 (Graphited)
20.75 lbs.

Rd. 17
12/19/52
Vel. 2963 f/s.
Press. 20.7 t.s.i.

0.001 SEC.
Shot ejection
Powder: EX-7020 (Graphited)
20.75 lbs.

Rd. 18
12/19/52
Vel 2957 f/s
Press. 20.8 t.s.i.

0.001 SEC.
Shot ejection
Powder: EX-7020 (Graphited)
20.75 lbs.

Rd. 19
12/19/52
Vel. 2956 f/s
Press. 22.3 t.s.i.

0.001 SEC.

55.200
P.S.I.

54.500
P.S.I.

53.000
P.S.I.

55.900
P.S.I.

54.000
P.S.I.

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Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES

Date: 1-27-53
Rd: 1
Velocity: 2761 F/s
Pressure: 18.8 T.S.I.

Powder: EX-7019
Charge: 17.00 lb

Close Firing Key

0.001 sec.

Shot ejection

Calibration

54.300
55.600
F.S.I.

Date: 1-27-53
Rd: 2
Velocity: 3084 F/s
Pressure: 22.4 T.S.I.

Powder: EX-6822
Charge: 21.56 lb.

Calibration

55.200
55.200
F.S.I.

Close Firing Key

0.001 sec.

Shot ejection

Date: 1-27-53
Rd: 3
Velocity: 3055 F/s
Pressure: 22.1 T.S.I.

Powder: EX-6822
Charge: 21.56 lb

Calibration

54.100
53.800
F.S.I.

Close Firing Key.

0.001 sec.

Shot ejection

Date: 1-27-53.
Rd: 4
Velocity: 2763 F/s
Pressure: 21.0 T.S.I.

Powder: EX-7019
Charge: 17.00 lb

Calibration

57.100
55.800
F.S.I.

Close Firing Key.

0.001 sec.

Shot ejection

Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES

Date: 1-27-53
Rd: 5
Velocity: 2773 f/s
Pressure: 21.3 T.S.I.

Powder: EX-7019
Charge: 17.00 lb

Calibration

55000
55.900
P.S.I.

Close Firing Key.

0.001 sec.

Shot ejection

Date: 1-27-53
Rd: 6
Velocity: 2763 f/s
Pressure: 20.2 T.S.I.

Powder: EX-7019
Charge: 17.00 lb.

Calibration

54600
54.600
P.S.I.

Close Firing Key.

0.001 sec.

Shot ejection

Date: 1-28-53
Rd: 1
Velocity: 2769 f/s
Pressure: 21.2 T.S.I.

Powder: EX-7019
Charge: 17.00 lb

Calibration

54800
54.800
P.S.I.

0.001 sec.

Shot Ejection

Date: 1-28-53
Rd: 2
Velocity: 3052 f/s
Pressure: 21.2 T.S.I.

Powder: EX-6883
Charge: 21.28 lb.

Calibration

56200
56.200
P.S.I.

0.001 sec.

Shot Ejection

Ballistic Test of Cool Propellants EX-7016-EX-7021 Inclusive,
EX-7038, and EX-7048-EX-7050 Inclusive

PRESSURE-TIME CURVES

Date: 1-28-53
Rd: 3
Velocity: 3055 f/s
Pressure: 21.9 T.S.I.

Powder: EX-6883
Charge: 21.28 Lb.

0.001 Sec.

Shot Ejection

Date: 1-28-53
Rd: 4
Velocity: 3071 f/s
Pressure: 21.2 T.S.I.

Powder: EX-6883
Charge: 21.28 Lb.

0.001 Sec.

Shot Ejection

Date: 1-28-53
Rd: 5
Velocity: 3068 f/s
Pressure: 22.3 T.S.I.

Powder: EX-6883
Charge: 21.28 Lb.

Close firing key

0.001 Sec.

Calibration

53.200
53.000
P.S.I.

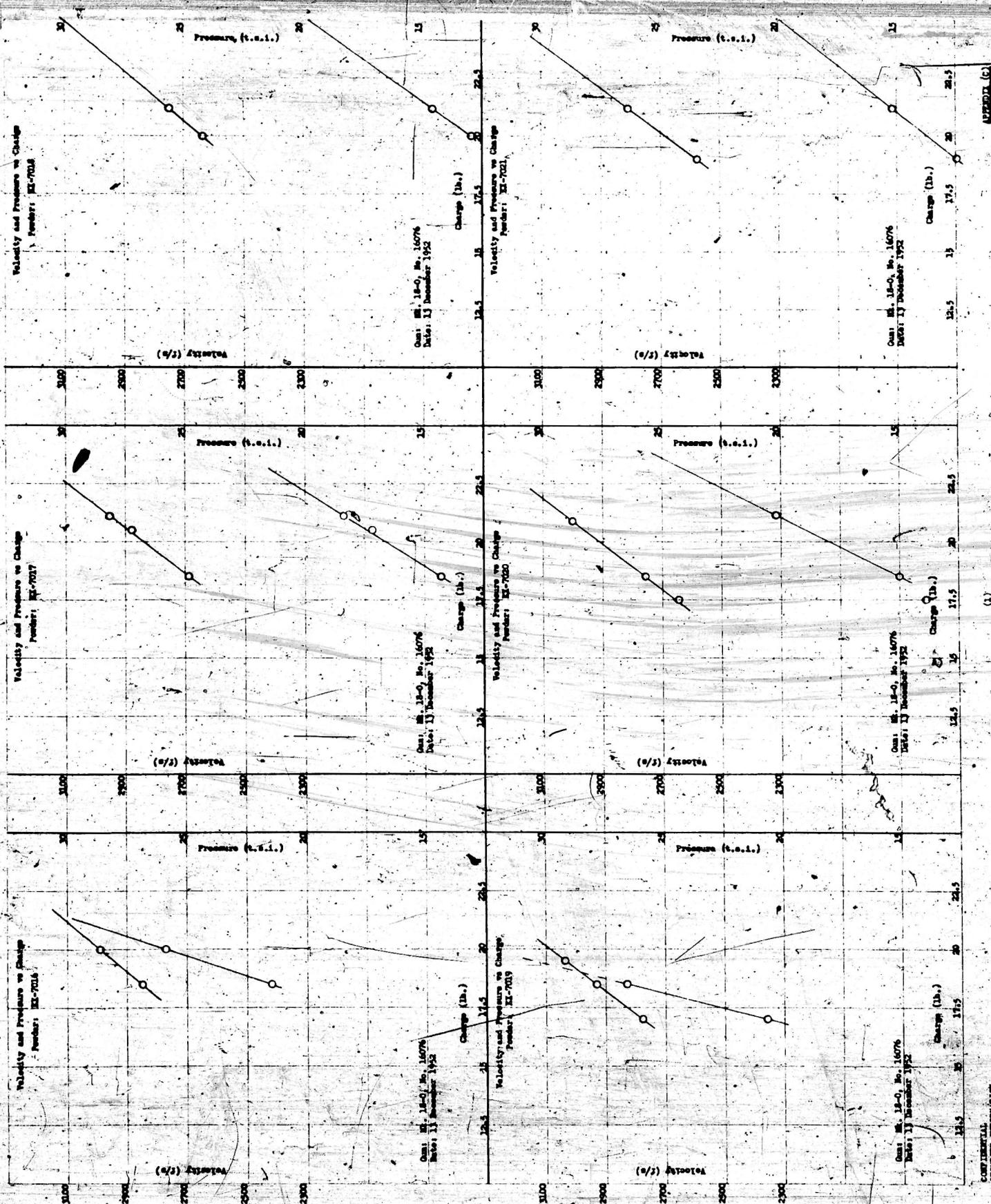
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Velocity: 3070 f/s
Pressure: 22.0 T.S.I.

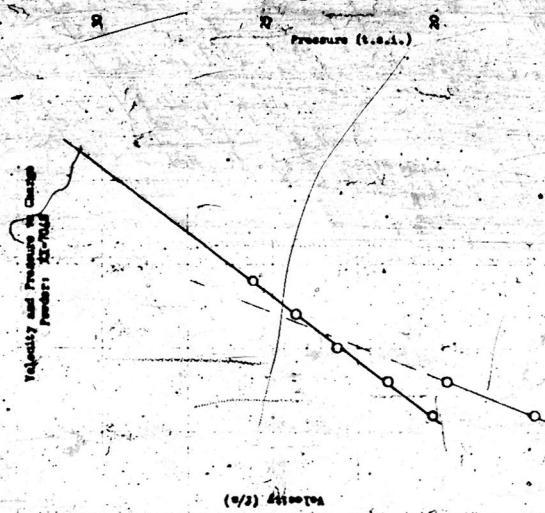
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Charge: 21.28 Lb.

0.001 Sec.

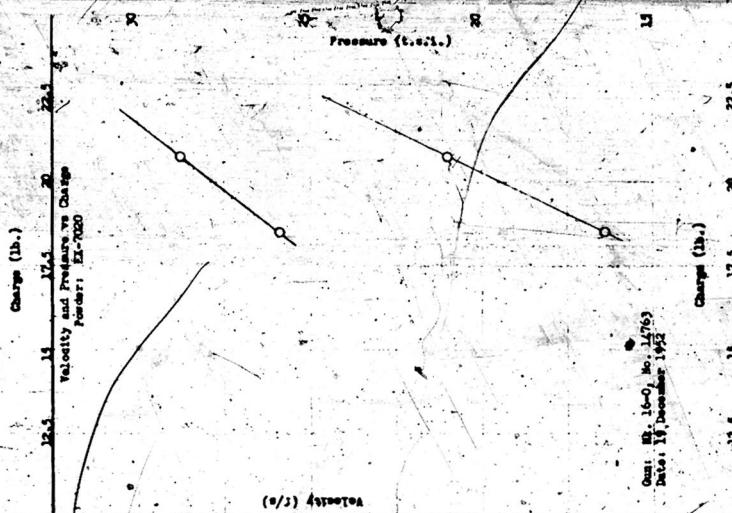
Shot Ejection

55.500
55.000
P.S.I.

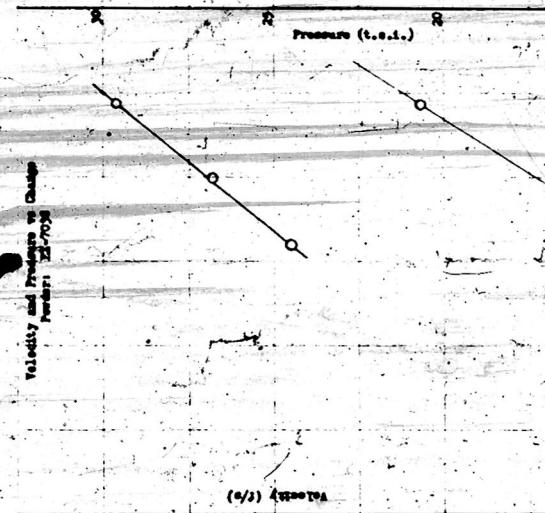




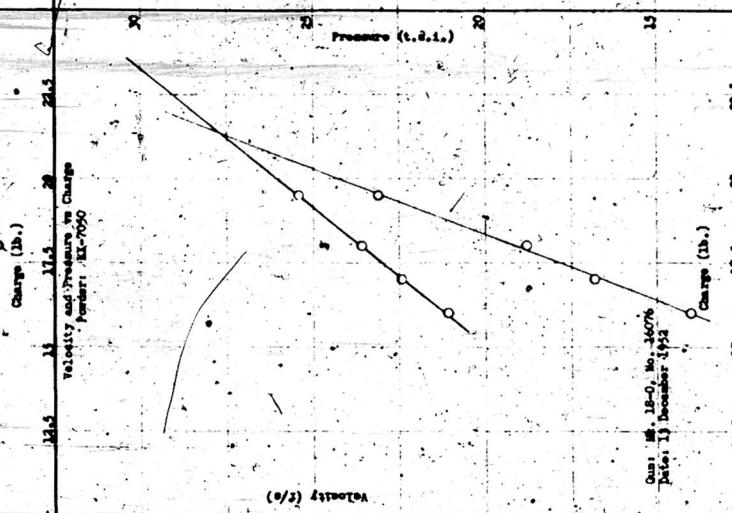
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Date: 13 December 1952



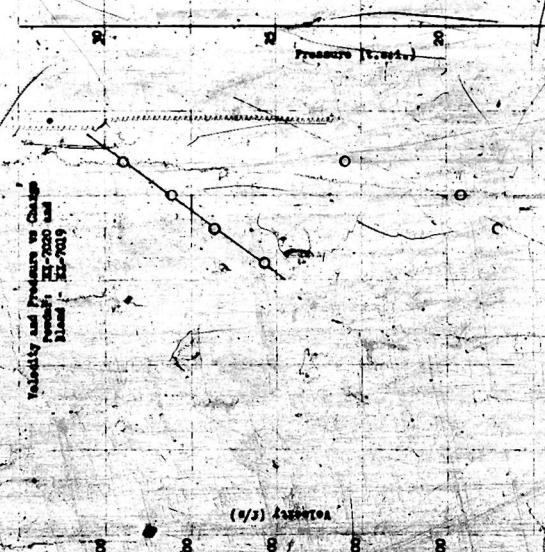
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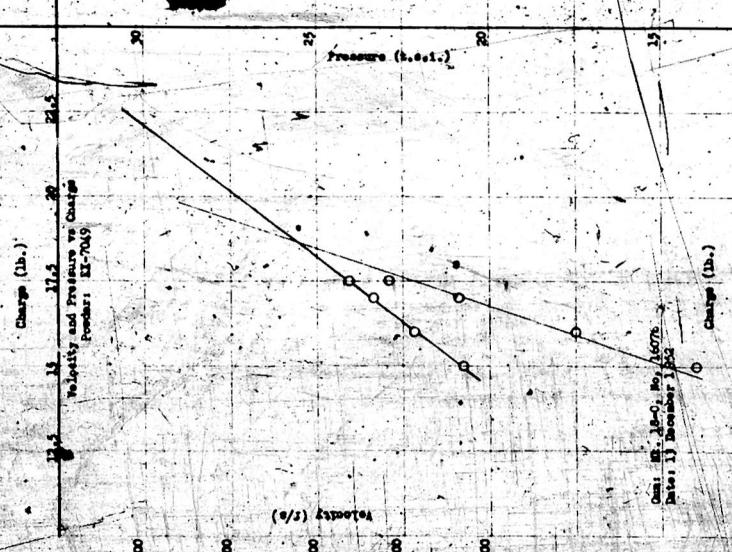
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Date: 13 December 1952



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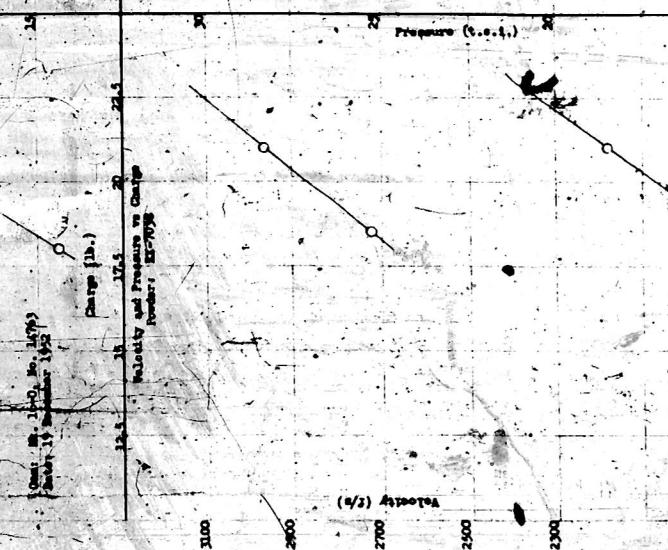
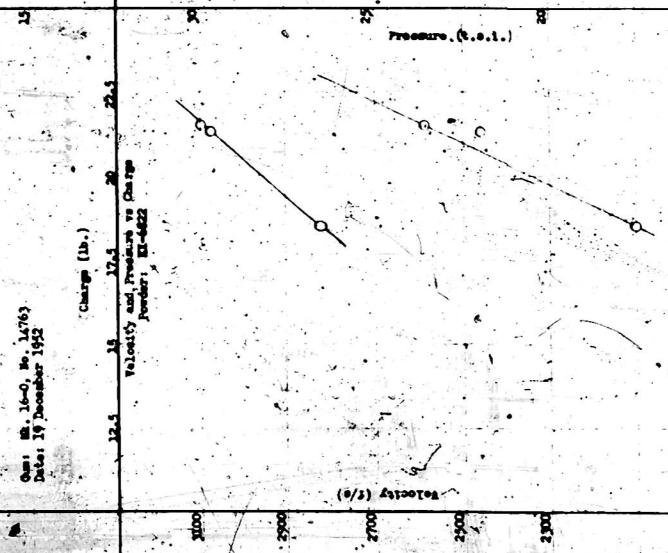
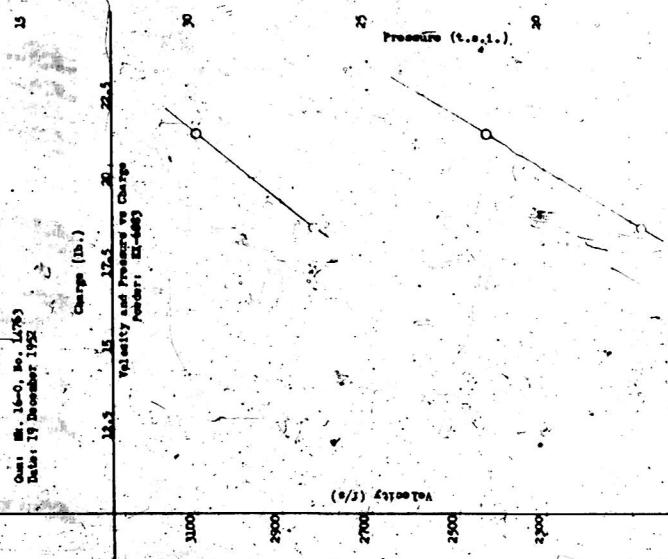
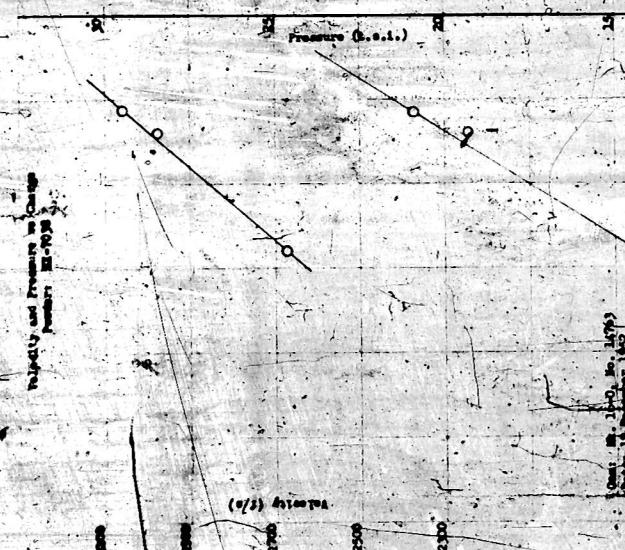
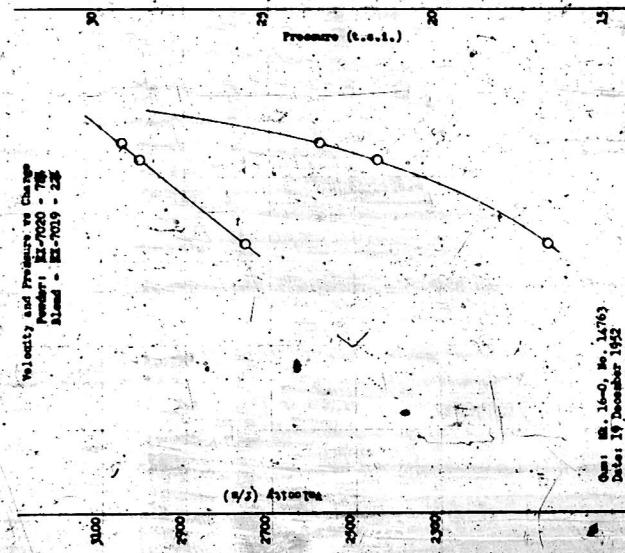
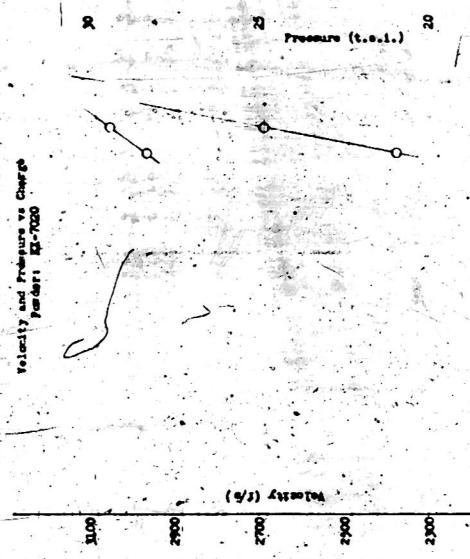


File No. 18-0, No. 15076
Date 11 December 1943



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BALLISTIC TEST OF COOL PROPELLANT



Ques: No. 18-0, No. 16077
Date: 2 January 1951

Ques: 10; 16-0, No. 16077
Date: 2 January 1953

Qm. 14-0, No. 1691